Preliminary Report on the Results of Biological Monitoring Activities Carried out on Birch Stream in Bangor, ME in Summer 2003

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TABLE OF CONTENTS

<u>State of Maine Health and Environmental Testing Laboratory (HETL)</u>

vii. Analysis of Trace Metals in Drinking Water
viii. Analysis of Total Kjeldahl Nitrogen in Waters
ix. Analysis of Nitrate + Nitrite in Drinking Water, Groundwater, Surface Water, and Wastewater
x. Analysis of Ammonia in Water
xi. Analysis of Total Phosphorus
xii. Analysis of Ortho Phosphorus
xiii. Chlorophyll (Note: this is not a HETL SOP but they use this method for the analysis of Chlorophyll *a*)
xiv. Substrate Test for the Detection and Enumeration of Total Coliforms and *E. coli* in Drinking Water and Ambient Freshwater. (Colilert, Colilert-18, Colisure)
xv. Analysis of Total Suspended Solids
xvi. Analysis of Chloride in Waters

EXECUTIVE SUMMARY

This executive summary briefly summarizes the contents of this report. More information on individual topics, findings, interpretations, and recommendations can be found in the sections given in parentheses at the end of each paragraph.

The Maine State Legislature in 1986 created the Water Classification Program so as to "restore and maintain the chemical, physical, and biological integrity of the State's waters and to preserve certain pristine State waters." This Program assigned classification standards to all surface waterbodies. In the case of rivers and streams, waters were classified as either Class AA, Class A, Class B, or Class C, and criteria for habitat, aquatic life, bacteria and dissolved oxygen were set to define those classifications. (see Introduction)

The Maine Department of Environmental Protection (MDEP) is charged with the task of safeguarding the health of Maine's rivers and streams. Within the MDEP, the Biological Monitoring Program has the responsibility to determine whether a waterbody meets the aquatic life standards of the water classification assigned to it under the Maine Water Classification Program. Since its beginnings in 1983, the Biological Monitoring Program has established almost 700 monitoring stations on approximately 240 rivers and streams throughout Maine. Samples of macroinvertebrates (small animals without a backbone, such as insects or worms) are collected and analyzed using standardized protocols and statistical models whose results indicate whether a waterbody meets its aquatic life criteria[1]. If these criteria are not met, the MDEP has a mandate to improve the conditions in the waterbody. Following this mandate, the MDEP develops a stream-specific Total Maximum Daily Load (TMDL) plan which specifies maximum pollutant loads aimed at returning aquatic life to healthy conditions. (see Introduction)

During the first fifteen years of its existence the Biological Monitoring Program primarily monitored the water quality of mostly large rivers and streams impacted by point source discharges that can be attributed to a distinct entity; for example a wastewater treatment plant, pulp and paper mill, or heavy industry operation. More recently, the Program has expanded to include smaller streams impacted by nonpoint source (NPS) pollution that originates from diffuse sources as opposed to a distinct entity. Urban development in particular has been found to be responsible for contributing NPS pollution to streams, causing problems such as water pollution with nutrients and heavy metals, increases in water temperature, changes in water cycling and movement patterns, and erosion in and adjacent to a stream. In several cases, the Biological Monitoring Program has shown that such problems lead to a degradation in the resident macroinvertebrate community, causing a stream to violate its aquatic life standards. To better understand the effects urban development has on small streams, the MDEP has launched the Urban Streams Project to identify specific problems caused by NPS pollution and suggest ways of solving those problems. (see Introduction)

[1] Note: It should be stressed that the MDEP Biological Monitoring Progam collects and analyzes all its data with the primary goal of identifying problems for macroinvertebrate communities in a stream. Data are in no way analyzed or interpreted with respect to human health issues

During the summer of 2003, the Urban Streams Project collected a wide variety of biological, chemical, and physical data on four streams in Maine. Birch Stream in Bangor was one of these four. Preliminary analysis of the results available to date indicate that, compared to a healthy stream, the following conditions exist in Birch Stream:

- Biological communities (macroinvertebrates and fish) are degraded. Animal diversity is low and most species present are known to be tolerant to pollution.
- Various water quality parameters (e.g., dissolved oxygen levels, water temperature, nutrient levels) are impaired. They are at levels that negatively affect biological communities.
- Instream habitat quality is compromised. The stream and its banks are eroding due to dramatically increased water flows after storms, and woody debris is absent from the stream causing a decrease in habitat diversity and food supply.

It is expected that as yet outstanding data will underscore the impaired nature of Birch Stream. One particular stressor that affected Birch Stream in the winter/spring of 2002/2003 was dramatically increased de-icer use by the Maine Air National Guard. Although the Urban Streams Project did not collect any data specifically relating to de-icer concentrations in the stream or their effect on biological communities, personal observations indicated the large quantities of de-icer entering the stream from the airport complex (i.e., from both the Air National Guard and Bangor International Airport) had a detrimental effect on macroinvertebrates. (see Results and Discussion)

Once data analysis is completed, the Urban Streams Project will develop a TMDL plan for Birch Stream. It is unclear at this point what specific pollutants or stressors the TMDL plan will address but it is likely that the following general recommendations will be considered during the TMDL development process (see Conclusions):

- Remove the de-icer from the stream (de-icer removal has already been initiated on the airport complex and future monitoring should be conducted to determine the effect this had on the stream)
- Reduce the water temperature in the stream
- Increase the dissolved oxygen level in the stream
- Reduce the nutrient and metal levels in the stream
- Improve habitat quality in the stream and the area adjacent to the stream (the riparian zone)

These recommendations are very general in nature, and development of the TMDL plan will require the input of experts such as biologists, geologists and engineers to tailor the contents of the plan to the specific conditions encountered in Birch Stream. Implementation of the TMDL plan should lead to a considerable improvement in the health of the stream and its resident aquatic communities over the next few years. Future monitoring is advisable to determine whether the TMDL plan achieved its goal of restoring aquatic life to Class B standards in Birch Stream, or whether additional actions are required. (see Conclusions)

INTRODUCTION

Rivers and Streams in Maine

The United States Clean Water Act of 1972 requires that states protect and maintain the chemical, physical and biological integrity of the nation's waters. In pursuit of this directive, the Maine State Legislature in 1986 created the Water Classification Program (Title 38 MRSA Art. 4-A) so as to "restore and maintain the chemical, physical, and biological integrity of the State's waters and to preserve certain pristine State waters." Recognizing it was unrealistic to assign the same environmental goals to all of the State's fresh surface waters, the Legislature adopted the following four Classes of fresh surface waters, excluding great ponds:

- Class AA Waters. Class AA is the highest classification and is applied to waters that are outstanding natural resources which should be preserved because of the ecological, social, scenic or recreational importance.
- Class A Waters. Class A is the second highest classification.
- Class B Waters. Class B is the third highest classification.
- Class C Waters. Class C is the fourth highest classification and establishes the State's minimum environmental goals.

The classification system was based on water quality standards that designated uses for each of the four water classes. For example, "Class B waters shall be of such quality that they are suitable for the designated uses of drinking water supply after treatment; fishing; recreation in and on the water; industrial process and cooling water supply; hydroelectric power generation, except as prohibited under Title 12, section 403; and navigation; and as habitat for fish and other aquatic life. The habitat shall be characterized as unimpaired."[1] To ensure that water quality was sufficient to protect the designated uses, the Legislature established narrative criteria (for habitat and aquatic life) as well as numeric criteria (for bacteria and dissolved oxygen). For example, "The dissolved oxygen (DO) content of Class B waters shall not be less than 7 parts per million (ppm) or 75% of saturation, whichever is higher, except that for the period from October 1st to May 14th, in order to ensure spawning and egg incubation of indigenous fish species, the 7-day mean DO concentration shall not be less than 9.5 ppm and the 1-day minimum DO concentration shall not be less than 8.0 ppm in identified fish spawning areas. Between May 15th and September 30th, the number of *Escherichia coli* bacteria of human origin in these waters may not exceed a geometric mean of 64 per 100 milliliters or an instantaneous level of 427 per 100 milliliters. Discharges to Class B waters shall not cause adverse impact to aquatic life in that the receiving waters shall be of sufficient quality to support all aquatic species indigenous to the receiving water without detrimental changes in the resident biological community."[1, 2]

The task of establishing whether the a river or stream meets its assigned water class criteria rests with the Maine Department of Environmental Protection (MDEP). Depending on the situation, various MDEP programs may be asked to assess water quality, and determine whether water quality standards are met. In the case of aquatic life criteria, assessments are

[1] Class B was chosen as an example here because Birch Stream is classified as a Class B stream.
[2] The abbreviations for dissolved oxygen (DO) and parts per million (ppm) are not used in the original text.

performed by the MDEP Biological Monitoring Program. The program began evaluating biological communities in rivers and streams in 1983, and by late summer 2003 had established close to 700 monitoring stations on approximately 240 rivers and streams throughout Maine. Biological data are collected in accordance with a standardized sampling protocol developed by the program, and are analyzed using statistical models. These models estimate the association of a biological sample to the four water quality classes defined by Maine's Water Classification Program (see above), thus indicating attainment or non-attainment of aquatic life standards. Findings of the Biological Monitoring Program are used to document existing conditions, identify problems, set water management goals, assess the progress of water resource management measures, and trigger needed remedial actions. More information on the Biological Monitoring Program can be found in Davies et al. 1999, MDEP BLWQ 2002 (see the References section at the end of this report), or on the following website: *www.state.me.us/dep/blwq/docmonitoring/biomonitoring*.

<u>Biological Assessments of Impacts of Urbanization on Streams</u>

During the first fifteen years of its existence, the Biological Monitoring Program primarily monitored the water quality of rivers and streams impacted by point source discharges, which predominantly affected larger waterbodies such as the Penobscot and Piscataquis rivers. Point source discharges are those that can be attributed to a distinct entity such as a wastewater treatment plant, pulp and paper mill, or heavy industry operation. More recently, biological monitoring has expanded to include streams impacted by nonpoint source (NPS) pollution. This has led to a focus on smaller waterbodies or waterbodies where it is presumed that nonpoint sources are the major cause of water quality impairment.

Nonpoint source pollution is defined as pollution that originates from a number of diffuse sources as opposed to a distinct entity. Land use activities related to development (urbanization), agriculture, forestry activities, and transportation, as well as deposition on land of particles from the atmosphere all may lead to NPS pollution. This type of pollution affects waterbodies in two ways: first, changes in land use patterns alter the local watershed hydrology, the water cycling and movement patterns within the specific land area that drains water into a body of water; and second, runoff from the land carries increased pollutant loads into waterbodies, leading to habitat alterations and to changes in the system of interactions between living organisms and the nonliving environment (i.e., ecosystem changes).

The specific effects of land use activities depend on the types of land uses occurring in a watershed and their extent. Development associated with urbanization is the greatest threat to water quality since it entails the most dramatic changes and is rapidly expanding while other types of land uses tend to be stable or declining. It is also typically an irreversible type of land use change. Urbanization leads to substantial increases in impervious surfaces that do not allow water to soak into the ground such as roads, rooftops, and parking lots. As a result, the amount of stormwater that runs off into a waterbody rather than soaking into the ground (the stormwater runoff) increases, usually in direct proportion to the extent of watershed imperviousness. At the same time, reduced water infiltration into the ground causes lower baseflows (the amount of water in a stream that comes from groundwater discharge), sometimes causing streams to entirely dry up during the warmest part of the year. The combination of increased stormwater runoff and reduced baseflow means that, in contrast to waterbodies in non-urbanized watersheds, waterbodies in urbanized watersheds tend to receive a proportionally greater amount of their flow from surface runoff than from groundwater. Elevated levels of surface, especially stormwater, runoff cause more frequent and extreme high flow events which can cause severe bank erosion and channel scouring to the extent that the morphology (structure) of a stream will change. Typically, a stream will become wider and shallower, and sediment loading from bank erosion and watershed sources increases. In addition to altering stream flow patterns, stormwater runoff can increase the concentration of water pollutants such as toxics like gas or oil from gas stations or garages, nutrients from fertilizers, bacteria from pet waste, or sediment from construction sites. Finally, runoff from hot pavements can increase stream water temperature to levels that are unhealthy for biological communities, an effect that can be exacerbated by the absence of shade-providing vegetation in the riparian zone adjacent to the stream.

The combined effects of land use changes within a watershed, particularly when associated with urbanization, can severely stress aquatic resources such as fish and macroinvertebrates (small animals that lack a backbone, for example insects or worms), leading to predictable changes in the instream biological community . Biological communities thus function as useful indicators of the health of a waterbody and can be monitored to determine the effects of human influences upon freshwater resources.

MDEP Urban Streams Project

The MDEP Biological Monitoring Program has identified a number of rivers and streams in Maine which are impacted by various types of land use changes. The Clean Water Act requires states to improve the quality of impacted streams by developing Total Maximum Daily Load (TMDL) plans aimed at removing or alleviating stressors that have been identified as causing an impairment. While traditional TMDL plans deal with pollutants that typically originate from point sources of pollution, pollutants originating from nonpoint sources are harder to deal with because of the absence of a distinct "polluter". To address this problem, the Biological Monitoring Program in early 2003 launched a pilot project to develop TMDLs dealing with NPS pollutants and the impairments they create. Under the Urban Streams NPS TMDL Project, or Urban Streams Project for short, a large amount of biological, physical, and chemical data has meanwhile been collected in four urban streams, including Birch Stream in Bangor. Once data collection and analysis have been completed, a comprehensive report summarizing the findings will be distributed to a group of experts (biologists, geologists, engineers) who will identify the particular stressors causing the impairments detected in the four study streams. Following the stressor identification process, recommendations for Best Management Practices (a practice or combination of practices that are deemed the most effective, practical means of reducing the amount of NPS pollution to a level compatible with water quality goals) and remedial actions aimed at removing or alleviating the stressors will be developed. These recommendations will help to inform the development of stream-specific TMDL plans whose implementation will hopefully allow the streams to recover.

Birch Stream in Bangor

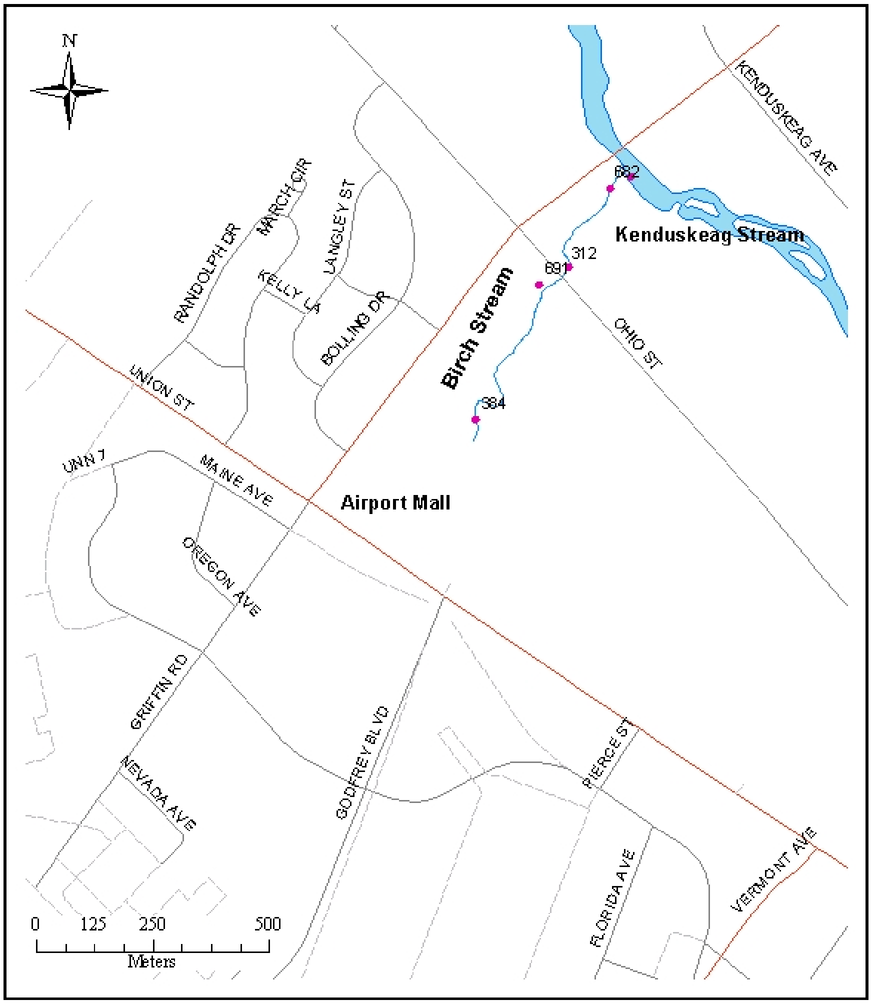
[**Note**: for the purposes of this report, "Birch Stream" refers to that portion of the stream that resembles a natural stream, i.e., the portion between the Airport Mall and the confluence with Kenduskeag Stream. Upstream of the Mall, Birch Stream largely has been channelized, rerouted, and the stream bed has been covered with concrete, making it unsuitable for colonization by macroinvertebrate communities, which are the focus of this study.]

Birch Stream (Fig. 1), one of the four streams in the Urban Streams Project, is located in Bangor in central Maine and is of short length (<1 mile) and relatively small watershed size (~940 acres). The watershed has a high percentage of impervious surfaces (~30 %) and is characterized by a variety of urban stressors including residential and commercial development, and an extensive transportation infrastructure (roads, airport). The ecological conditions in the watershed have likely declined during the last few decades, largely because of increasing urbanization of the area. Birch Stream was additionally impacted during the winter of 2002/2003 because of increased de-icer use by the Air National Guard (ANG) stationed at the Bangor International Airport (BIA) complex. Large amounts of de-icer originating from both the ANG and BIA entered Birch Stream untreated and caused a deterioration in water quality; i.e., strong noxious smell, milky appearance of water, extensive growth of bacterial mats (personal observation).

Data collected by the MDEP Biological Monitoring Program in 1997, 1999, and 2001 indicated that Birch Stream violated the aquatic life criteria of its assigned Water Classification Class, Class B (see Previous Studies, Maine DEP BLWQ Macroinvertebrate Assessment, below). Because of these violations, the stream is scheduled for TMDL development based on the data gathered in the Urban Streams Project. Existing data also suggest that problems exist with a number of water quality parameters (e.g., dissolved oxygen, some nutrients and heavy metals) at some locations on some occasions. These impairments likely can be attributed to the effects of extensive impervious surfaces with their associated usages, such as retail and industrial complexes, roads, parking lots, airport, etc.

This report presents the data that are available and have been analyzed to date (December 2003), and puts them into the context of stream health. Because sampling was undertaken with the specific goal of identifying stressors for the aquatic communities in Birch Stream, no references will be made to human health. The data contained in this report should in no way be used to make inferences on the effect of Birch Stream's water quality on human health. A full scientific report on all the findings of the Urban Streams Project in all four study streams will likely be completed in late spring 2004, recommendations for improvements will be made in the summer of 2004, and TMDL plans will be developed between the fall of 2004 and spring of 2005. It is expected that the MDEP Biological Monitoring Program will continue to assess the macroinvertebrate community in Birch Stream approximately every 2-3 years for the foreseeable future.

Fig. 1. Map of Birch Stream in Bangor



Biological Monitoring Stations
384, behind Airport Mall, Rt. 222 (above large beaver dam)
691, above Ohio Street crossing (not included in report)
312, below Ohio Street crossing (above waterfall)
682, upstream from confluence with Kenduskeag Stream (below waterfall)

PREVIOUS STUDIES

<u>Maine DEP BLWQ Macroinvertebrate Assessment</u>

The Biological Monitoring Program of the Maine DEP's Bureau of Land and Water Quality (BLWQ) collected macroinvertebrate data in 1997, 1999, and 2001 at the middle station (312, Fig.1), and in 2001 at the upstream station (384). Sampling collection and processing methods are detailed in Davies and Tsomides (2002, App. i), and briefly described in Sampling Methods, Biological Monitoring, below. Macroinvertebrate samples were sorted at the MDEP laboratory and identified by either Lotic, Inc (Unity, ME) or Freshwater Benthic Services (Petosky, MI). The MDEP analyzed taxonomic data using a statistical model which assigned samples to one of three State of Maine water quality classes (A[3], B, or C) or to a Non-Attainment category.

Model results indicated that the biological communities at both stations were degraded in all sampling years, with the dominant organisms consisting of the tolerant midge larvae (immature stages of a type of fly) and leeches. The macroinvertebrate community at the middle station did not meet the minimum (i.e., Class C) aquatic life standards in 1997, although it met those standards in 1999 and 2001; this was, however, still below the Class B standard that Birch Stream has to attain. The macroinvertebrate community at the upstream station did not meet the minimum aquatic life standards in the single year it was sampled, 1999. Water quality data collected at the middle station showed good dissolved oxygen levels (9.6 and 8.4 mg/L in 1999 and 2001, respectively) but high conductivity levels (370, 586, and 434 μS/cm in 1997, 1999, and 2001, respectively); similar data were recorded at the upstream station (9.6 mg/L for dissolved oxygen, and 622 μS/cm for conductivity in 1999). For an explanation of dissolved oxygen and conductivity see Sampling Methods, Water Quality Monitoring, below.

<u>Maine DEP BRWM Sediment and Surface Water Sampling</u>

In early June 2003, Division of Remediation staff from the Maine DEP's Bureau of Remediation and Waste Management (BRWM) sampled sediments at three stations and surface waters at four stations on Birch Stream. Surface water and sediment samples were analyzed for metals, semi-volatile and volatile organic compounds, and PCBs/pesticides. A report on the sampling efforts and resulting findings (Maine DEP, 2003) can be downloaded from the MDEP's website using the following link: *www.state.me.us/dep/rwm/rem/birchstream/*.

<u>Maine Air National Guard</u>

Staff from the Maine Air National Guard (ANG), which is located in the airport complex upstream of Birch Stream, sampled the airport drainage system and the stream itself in April 2002, May 2003, and September 2003. Surface water samples were analyzed for chemical and biological oxygen demand, propylene glycol, semi-volatile and volatile organic compounds, oil and grease, total suspended solids, ammonia, cyanide, and heavy metals (including mercury). Results from the first two sampling events are presented in App. A of the BRWM report cited above. Data summaries for the ANG samples can be obtained from Major Eric Johns at the ANG.

<u>Bangor International Airport</u>

The Bangor International Airport (BIA) contracted Civil Engineering Services, Inc., (CES) to sample sediment and surface water from various locations within the airport drainage areas and Birch Stream in August 2003. Sediment samples were analyzed for Diesel Range Organics and Gasoline Range Organics, and Sulfide; surface water samples were analyzed for Ethylene Glycol and Propylene Glycol. A copy of the CES report can be obtained from Rodney Madden at BIA.

[3] For the purposes of the statistical model, water quality classes AA and A are combined.

SUMMER 2003 STUDY

SAMPLING METHODS

This section describes the methods used by Maine DEP BLWQ staff to collect data in 2003. Sampling concentrated on the middle and downstream stations on Birch Stream (312 and 682, respectively; Fig. 1). The upstream station below the Airport Mall (384) had become ponded since the previous sampling event in 1999 due to the construction of a beaver dam and was therefore not re-sampled.

Biological Monitoring

1. The macroinvertebrate community was sampled once at the two stations (see Fig. 1) during a 4-week period in July and August 2003 using the protocol detailed in Davies and Tsomides (2002; App. i). Briefly, at each station, three replicate rock bags (Fig. 2) were deployed in the stream for ~28 days in riffle/runs. At the end of the colonization period, the bags were retrieved and the contents washed into a sieve bucket. These contents were transferred into labeled mason jars and preserved with 70% ethyl alcohol. Samples were sorted at the MDEP laboratory, and will be identified by a macroinvertebrate taxonomist. Biological data will be analyzed using a statistical model which assigns samples to State of Maine water quality classes (see Introduction, Maine's Rivers and Streams), or to a Non-Attainment category.

Fig. 2. Rockbag

2. The fish assemblage at both stations was investigated by staff of the MDEP Rivers section by electrofishing a 60-100 m long stretch, recording data on species composition and fish length. Details about the survey technique and equipment is given in App. ii. Fish diversity in Maine rivers and streams is generally fairly low compared to many other parts of the country, but a healthy stream the size of Birch Stream could be expected to have around 6-7 different species, including Brook Trout, Sticklebacks, Blacknose Dace, Golden Shiner and Creek Chub. The diversity of fish actually encountered in a waterbody gives an indication of the health of the entire system.

Water Quality Monitoring

1. Standard water quality parameters (instantaneous dissolved oxygen, and specific conductance) were monitored at both stations using electronic field meters as detailed in App. iii. Measurements were taken nine times during the period May through October at the middle station, and twice at the downstream station (in August and September during deployment and retrieval of macroinvertebrate samplers). Dissolved oxygen (DO) levels are important for all aquatic fish and invertebrates as oxygen is required for respiration. Specific conductance, also often referred to as conductivity, is a measure of the ability of water to conduct an electrical current, which is related to the concentration of ions in the water. As many of these ions can originate from human sources (e.g., fertilizers, road

salts, metals abrading from car breaks and tires), specific conductance can be used as an indicator of water pollution.

2. Temperature was monitored continuously from June 26 through September 26 at the middle station, and from July 30 to August 27 at the downstream station using Optic Stowaway temperature loggers. Detailed information on the loggers and their use can be found in App. iv. Summer temperature is an important instream parameter as many coldwater organisms can be severely stressed above 21º C.
3. Water chemistry parameters were sampled as shown in Table 1.

Table 1. Sampling schedule (parameters, stations, dates in 2003) for Birch Stream.

Parameter Station	Middle (312)	Downstream (682)
Nutrients		
Total Kjeldahl Nitrogen, Nitrate-Nitrite-N, Total Phosphorus	7/16, 8/13, 8/27, 9/10	8/27
Ammonia	8/27	8/27
Orthophosphate	7/16, 8/13, 9/10	
Dissolved Organic Carbon	8/13, 8/27	8/27
Total Organic Carbon	8/13	
Chlorophyll *a*	7/16, 8/13, 9/10	
Total Suspended Solids	7/16, 8/13, 8/27, 9/10	8/27
Bacteria (*E. coli*)	7/16, 8/13, 9/10	8/13, 9/10
Metals		
Cadmium, Copper, Iron, Lead, Zinc	7/16, 8/13, 9/10	
Chromium, Nickel	8/13	
Chloride	8/13	

Detailed information on the sampling and analysis protocols for these parameters can be found in Appendices v, and vii - xvi. The chain-of-custody form required by the analytical laboratory (State of Maine Health and Environmental Testing Laboratory, HETL) was completed upon sample delivery to the laboratory. Water chemistry parameters generally indicate the degree of pollution of a waterbody due to human activities. Heavy metals can be toxic to organisms above certain levels while an abundance of nutrients can lead to increased algal growth which in turn can cause oxygen depletion. Bacteria are not generally of concern for aquatic organisms; however, bacteria can be a problem if they are of human origin and if a waterbody is classified as suitable for recreation in and on the water (as Birch Stream is). It must be noted that in this study samples were analyzed simply for the presence of bacteria with no regard for their origin. Potential origins other than humans include wildlife (e.g., deer), birds (e.g., ducks), or pets, all of which can be found on or around Birch Stream.

Habitat Assessments

1. The variability of the flow regime in the thalweg of the stream channel (the deepest, fastest-flowing part) was studied by measuring water velocity every 2 m along a 100-m long stretch of stream, starting at the rockbag location and proceeding upstream. These

data were collected once in early September at the middle station using a Global flow meter as detailed in App. vi. A variable flow velocity regime is an important factor in habitat quality as it provides a wide range of environments for fish and invertebrates to occupy.

2. The abundance and size structure of woody debris was evaluated by measuring the mean diameter of all pieces of woody debris (branches, tree trunks) found inside the channel at the middle station; this was done once in early September. Woody debris is important as it provides stable attachment sites for macroinvertebrates, provides and traps organic material for consumption by microbes and macroinvertebrates, allows the formation of pools for fish, and traps sediment.

3. Stream habitat was surveyed by walking the entire length of Birch Stream and identifying major topographic features (waterfall), man-made structures (bridge), potential erosion problems, and other noteworthy features (beaver dams); this was done once in early November 2003.

RESULTS AND DISCUSSION

Biological Monitoring

1. Macroinvertebrate samples collected from rockbags in August after an exposure period of four weeks in the stream have been sorted to separate animals from debris (pieces of wood, leaves, grasses, sand, etc.). A visual analysis indicated a degraded community with a low diversity of animals with the majority of the sample consisting of the tolerant organisms leeches and midge larvae. The samples will be sent out for identification by a macroinvertebrate taxonomist, whose list of the exact numbers and types of organisms identified is expected in late winter/early spring of 2004. These samples will then be analyzed statistically by the MDEP to aid in determination of water quality conditions.

   The degraded macroinvertebrate community identified by visual analysis is indicative of a stream that is of poor water quality (DO, temperature, nutrients; see following section), and has a reduced food supply (leaf and woody debris input), and inadequate habitat (see section on Habitat Assessments). It is very likely that in 2003, as in previous years (see Previous Studies, Maine DEP BLWQ Macroinvertebrate Assessment), Birch Stream will not meet the Class B aquatic life standards although this can only be confirmed once taxonomic data have been analyzed statistically (see Introduction, Rivers and Streams in Maine). This result is not unexpected given that conditions in the watershed have worsened (i.e., de-icer use by the ANG and BIA, see Introduction, Birch Stream in Bangor) since the previous sampling event. Degraded macroinvertebrate communities similar to the one found in Birch Stream also have been found in other urban streams sampled by the Biological Monitoring Program.

   The data collected in this study (as presented in following sections as well as data not yet available) will be analyzed with the goal of identifying specific stressors that are responsible for the observed impairment in the macroinvertebrate community. Although the Urban Streams Project did not collect data specifically relating to de-icer concentrations in the stream or their effect on biological communities, personal observations indicated that the large quantities of de-icer entering the stream from the airport complex had a detrimental effect on macroinvertebrates. However, the stressor identification process may point to a whole suite of factors that need to be addressed to restore healthy aquatic communities in Birch Stream. At this point it seems probable that in addition to the de-icer (which the ANG has started to contain, see Conclusions), high water temperatures, the altered hydrology with excessive storm flows, and overall poor water quality are potential stressors. Suggestions on how to deal with these stressors will be made in the respective sections below.

2. The fish assemblage found at the middle station consisted of only one single fish, a 9-spine Stickleback (2.5" in length). At the downstream station, fish diversity was much higher, with one Brook Trout (3"), six Golden Shiner (2-3"), 13 American Eel (6-20"), one White Sucker (4"), six Creek Chub (6"), one Banded Killifish (3"), and more than 50 Blacknose Dace (1.5-3").

   The low fish abundance and diversity above the waterfall is likely the result of the poor water quality (e.g., low dissolved oxygen, high temperature) in this section, and the absence of a refuge from where fish populations could be replenished after a significant decline. Restocking this upper section of Birch Stream with native fish might be considered at a later point in time when the water quality has been restored, as the waterfall presents an insurmountable barrier to fish movement, eliminating the potential for natural recolonization. Advice on this issue should be requested from the MDEP's River section and the Maine Department of Inland Fish and Wildlife.

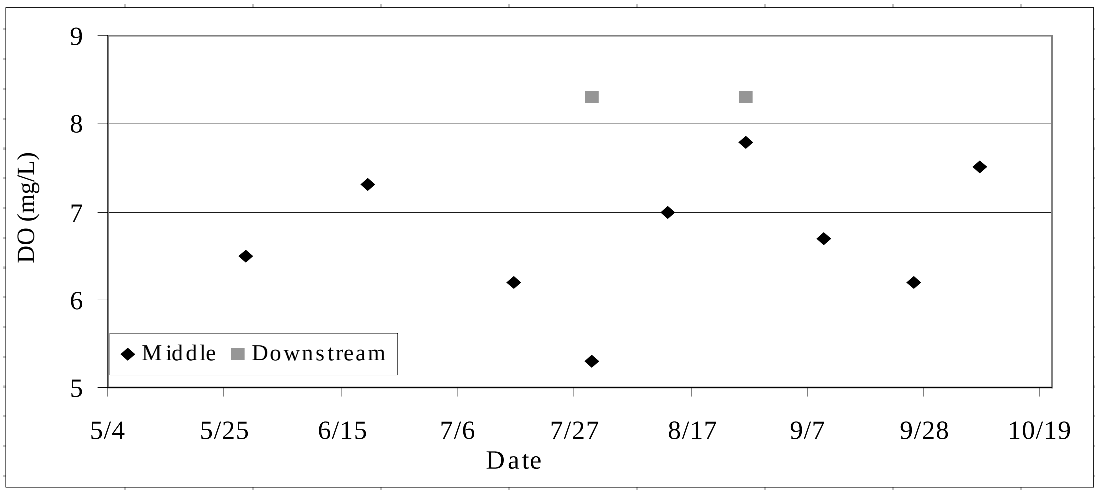
   The abundance of fish below the waterfall is likely attributable to the proximity of Kenduskeag Stream, which allows fish to swim in and out of Birch Stream. The presence of Brook Trout at the station was surprising as the water quality in Birch Stream seems insufficient to support a relatively sensitive species like Brook Trout. However, the one individual observed was not healthy-looking, perhaps reflecting the low water quality. All other species observed are known to be tolerant to water pollution, reflecting the poor water quality. The proximity of Kenduskeag Stream is a positive factor as it will allow natural recolonization of the lower section of Birch Stream by more sensitive species once the water quality and instream habitat have been improved.

<u>Water Quality Monitoring</u>

1. Standard water quality parameters

   The levels of instantaneous dissolved oxygen (DO) at the middle station on Birch Stream were quite variable, with a low of 5.3 mg/L in late July, and a maximum of 7.8 mg/L in late August (Fig. 3). At the downstream station, DO levels were at 8.3 mg/L on both sampling occasions (late July and late August).

Fig. 3. Instantaneous dissolved oxygen in Birch Stream

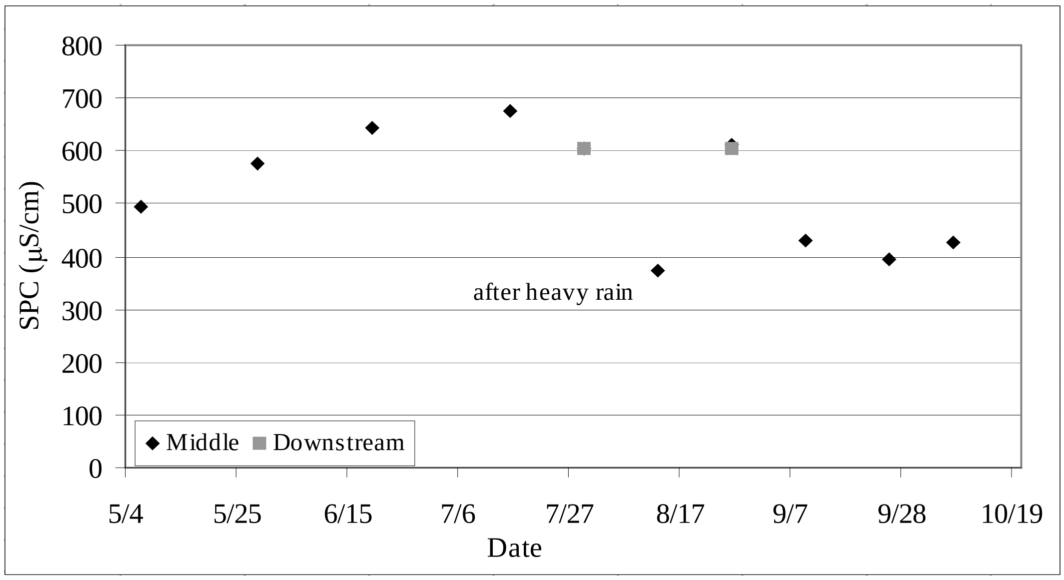


The dissolved oxygen (DO) levels in Birch Stream above the waterfall were below the Class B numeric criterion for summer DO levels (7 mg/L) on several occasions, thus violating water quality standards. To a certain extent, this may be attributable to the high summer water temperature found in Birch Stream (see Temperature, below) because warm water can hold less DO than cold water. Other factors that can influence DO levels are the abundance of algae (which both produce and consume oxygen) or microorganisms (e.g., some bacteria use oxygen for respiration), flow patterns (riffle sections of a stream help to re-aerate the water), and the presence of nutrients in the water (which can influence the abundance of algae). In Birch Stream, the algal cover was not of an extent that could seriously affect DO levels (T. Danielson, MDEP Biological Monitoring Program, personal communication), and it will require further analysis to determine what factor, or combination of factors, is governing the oxygen regime in this stream.

Dissolved oxygen (DO) is required for respiration by all aquatic animals, but some organisms, such as trout or mayflies, require relatively high oxygen levels for healthy functioning. Insensitive organisms like leeches or some worms, on the other hand, can survive at low DO levels. It should be noted that very few sensitive organisms (one Brook Trout encountered during electrofishing and no insects, as indicated by visual sample analysis) were found even below the waterfall where the DO level was much higher than above it. The elevated DO level in this lower stretch was likely due to re-aeration of the water in the waterfall. Overall, it is likely that DO levels in summer are not high enough to support healthy aquatic communities. A reduction in water temperature and general improvement in water quality should allow this parameter to return to healthy levels.

Like instantaneous DO levels, instantaneous levels of specific conductance (SPC, also “conductivity”) at the middle station were quite variable, with minimum and maximum values of 373 and 677 μS/cm, respectively (Fig. 4). At the downstream station, conductivity levels were at 606 μS/cm on both sampling occasions (late July and late August). As noted on Figure 4, the minimum value of 373 μS/cm was recorded after heavy rain (0.54”) the previous day, leading to a dilution of the conductivity.

Fig. 4. Specific conductance levels in Birch Stream

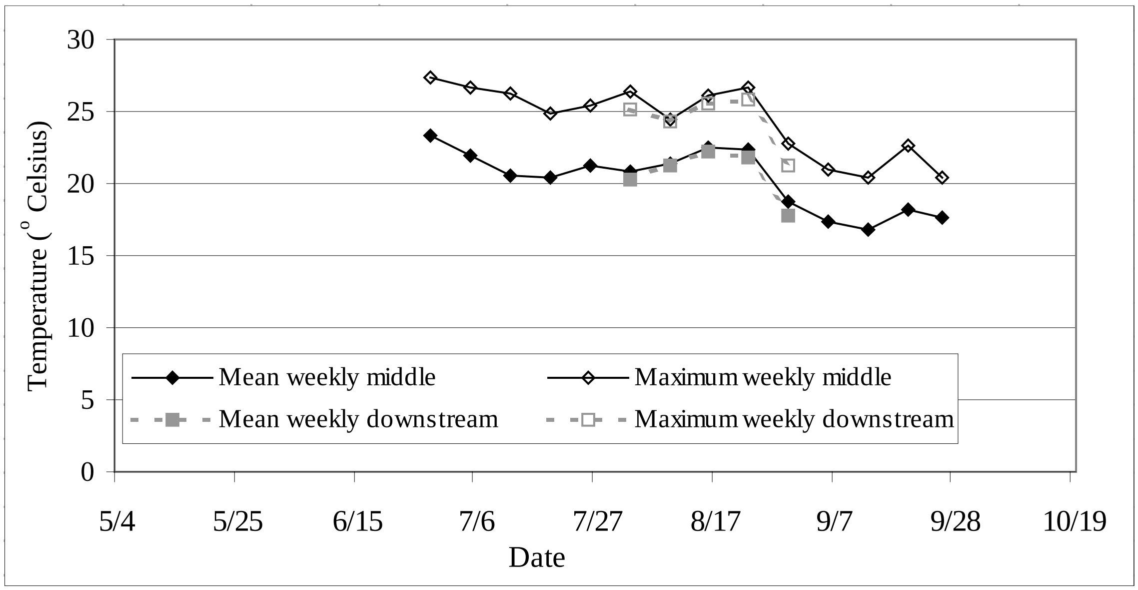


The levels of specific conductance in Birch Stream are similar to those found by the Biological Monitoring Program in other urban streams. These levels are much higher than those that would be encountered in pristine streams, where conductivity is typically well below 100 µS/cm (personal observation). While certain types of geological formations and certain soil types in the watershed can cause conductivity levels to be elevated naturally, it is likely that runoff from roads and the airport complex contributes to a high conductivity in Birch Stream. Even as far back as 1997, conductivity levels measured by the Biological Monitoring Program were elevated (370-622 µS/cm in 1997-2001), indicating that problems have existed in the watershed for several years.

While it is not known how conductivity in and of itself may impact biological communities, it is known that heavy metals, which can cause high conductivities, can have negative effects on aquatic life (see 3. Water chemistry, Metals, below). In order to reduce conductivity levels in Birch Stream, it would be important to improve the quality of the airport, road and parking lot runoff the streams receives, for example by channeling it through a stormwater treatment system.

1. Water temperature
   The temperature regime at the middle station (solid lines in Fig. 5) showed a mean weekly temperature above 20º C from late June to mid-to-late August, and a maximum weekly temperature at or above 25º C during that same period. After mid-to-late August, the mean temperature dropped to 17-19º C, and the maximum to 20-23º C. Temperatures measured at the downstream station (dashed lines) were similar to those measured at the middle station where dates overlapped.

Fig. 5. Continuous temperature in Birch Stream



The relatively high mean and maximum temperatures recorded in midsummer in Birch Stream were in a range that is considered stressful for many fish and aquatic invertebrates. In late summer, the mean temperature dropped to a more acceptable level although the maximum temperature still was above 20º C. Studies have shown that sensitive macroinvertebrates such as certain mayflies or stoneflies prefer temperatures below 17º C, while sensitive fish such as Brook Trout prefer temperatures below 20-22º C (see references in Varricchione 2002). Thus, as a prerequisite for restoring healthy biological communities, water temperatures in Birch Stream must be lowered in summer.

High water temperatures are often associated with open stretches of stream, where the absence of vegetation in the riparian zone leaves the water fully exposed to solar heating. This is the case in the section of Birch Stream above the Ohio Street bridge. Also, the pond-like situation created by the beaver dam below the Airport Mall could serve as a large heat reservoir, helping to maintain high temperatures for an extended distance downstream. Finally, heated runoff from impervious surfaces close to the stream can significantly increase water temperatures. To lower water temperatures to a summertime level that promotes healthy biological communities in the stream, a priority should be to replant the riparian zone between above the Ohio Street bridge (but see replanting note under “Woody debris”). Furthermore, removal of the beaver dam should be considered, although this is a complex issue whose various sides need to be considered carefully before any action is taken (see Habitat Assessments, habitat survey, below).

2. Water chemistry

Water chemistry data from three to four sampling events are summarized in Table 2. The table shows the results from three sampling events at the middle and downstream stations on Birch Stream, and how the results compare with various types of numeric criteria for aquatic life. These criteria define acute (brief exposure) or chronic (indefinite exposure) levels above which certain compounds can have detrimental effects on aquatic organisms. Highlighted fields in the table indicate cases where the sampling results exceeded the numeric criteria, i.e., cases where negative effects may be expected to occur in aquatic organisms. Exceedances were found for two nutrients for which criteria exist (Total Nitrogen and Total Phosphorus), as well as for Chlorophyll *a*, and bacteria (*E. coli*). None of the metals analyzed exceeded chronic or acute criteria although in some cases (Cadmium, Copper, Lead) the sensitivity of the analysis was not sufficient to determine whether criteria were exceeded. Chloride values were well below aquatic life criteria.

Nutrients and bacteria. The surface water samples analyzed exceeded aquatic life criteria for Total Nitrogen (the sum of Total Kjeldahl Nitrogen, Nitrate-Nitrite-N, and Ammonia) and Total Phosphorus), Chlorophyll *a*, and bacteria (*E. coli*). Nutrient levels are often increased in urban streams as runoff from land includes material that is high in nitrogen and phosphorus, such as animal waste, fertilizers, or septic effluent. However, for a variety of reasons nutrient levels typically encountered in urban streams do not appear to have a major influence on macroinvertebrate communities (personal observation). These reasons include rapid uptake of nutrients by plants, flushing of nutrients out of the system by high flows, and the presence of other, more significant stressors. The high Chlorophyll *a* values found are likely related to high nutrient levels as the algal concentrations measured with this parameter respond favorably to nutrient input. High bacteria levels may be attributable to a variety of sources, from pets to wildlife to birds to leaking sewer systems. The analysis performed in this study did not differentiate among these sources, but it is known that deer and waterfowl use Birch Stream as a resource, and are a likely source of bacteria. A distinct sewer smell was noted on various occasions just below the downstream sampling station (near the confluence with Kenduskeag Stream), and a potential sewer leak in this area should be investigated.

Measures aimed at reducing nutrient levels could include practices such as keeping pets away from the stream, picking up pet waste, ensuring that any septic systems in the watershed are in good working order, and that lawns in the vicinity of the streams are not fertilized. As nutrients generally are not major stressors in streams unless they are present in very high concentrations, these practices should be sufficient as initial steps aimed at controlling nutrient levels in Birch Stream. These practices also should help to reduce bacterial contamination.

Table 2. Results from waters chemistry sampling on Birch Stream

Parameters	Station (#)	Middle (S312)				Downstream (S682)			Aquatic Life Criteria	
	Sample date	16-Jul	13-Aug	10-Sep	27-Aug	13-Aug	10-Sep	27-Aug		
	Unit									
Nutrients										
Total Kjeldahl Nitrogen	mg/L	1.2	0.4	0.3	0.4			0.3	NC	
Nitrate-Nitrite-N	mg/L	0.29	0.35	0.48	0.34			0.33	NC	
Ammonia	mg/L				0.03			0.01	NC	
Total Nitrogen	mg/L	1.49	0.75	0.78	0.77			0.64	0.38 [1]	
Orthophosphate	mg/L	0.014	0.011	0.007					NC	
Total Phosphorus	mg/L	0.1	0.054	0.035	0.028			0.026	0.01 [1]	
Dissolved Organic Carbon	mg/L		1.8		3.3			3.4	NC	
Total Organic Carbon	mg/L		2						NC	
Chlorophyll *a*	mg/L	~0.0071	~0.0037	~0.0017					0.00063 [1]	
Total Suspended Solids	mg/L	4	5	2	2			2	NC	
Bacteria *(E. coli)*	# col./100 ml	687	1203	488		1120	248		427 [2, 3]	64 [2, 3]
Metals									**CMC**[4]	**CCC**[4]
Cadmium	µg/L	ND 0.5	ND 0.5	ND 0.5					0.64	0.32
Copper	µg/L	ND 5	ND 5	ND 5					3.89	2.99
Iron	µg/L	590	830	430					NC	1,000
Lead	µg/L	ND 3	ND 3	ND 3					10.52	0.41
Zinc	µg/L	ND 5	8	ND 5					29.9	27.1
Chromium	µg/L		1						16	11
Nickel	µg/L		ND 4						363.4	40.4
Chloride	mg/L		44						860	230

Highlighted fields indicate problem parameters

NC, no criteria

ND, below stated detection limit of test

[1] Criteria developed by EPA for Ecoregion VIII, which includes Birch Stream.

[2] Criteria (mean or instantaneous counts of the number of *E. coli* colonies) defined by Maine's Water Classification Program for Class B waters, which include Birch Stream.

[3] Results presented here are for bacteria of **any** origin while Maine Class B standards are for bacteria of **human** origin (see Introduction, Rivers and Streams in Maine). Note that in some studies where the origin of bacteria samples has been investigated, the majority of bacteria were **not** of human origin.

[4] CMC, Gold Book Instream Acute Criteria; CCC, Gold Book Instream Chronic Criteria. CMC and CCC, which were developed by EPA, denote the level of pollutants above which aquatic life may show negative effects following brief (acute) or indefinite (chronic) exposure.

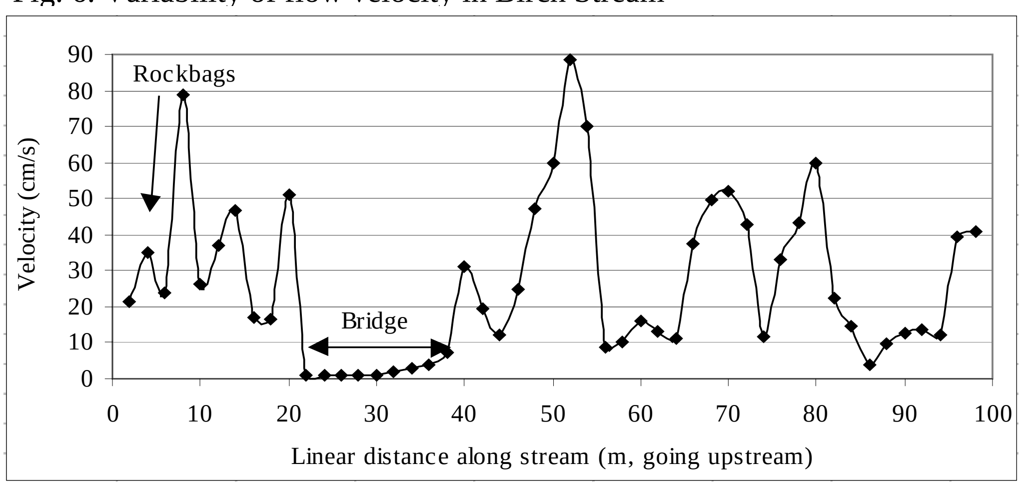
Metals. None of the seven heavy metals sampled in this study, or chloride, exceeded aquatic life criteria. Unfortunately, the detection limits for some metals (i.e., the lowest level of a component that can be reliably detected by a specific analytical procedure) were above the aquatic life criteria, for example in the case of copper for both chronic and acute criteria, and in the case of cadmium for chronic criteria. It should be noted that all metal data available at this point were collected during dry periods, with storm event data expected some time in January. Varricchione (2002) studied a stream (Long Creek) in a highly developed area in South Portland, and detected high metal levels during storm events. Given Varricchione's findings, it is likely that Birch Stream, which is also located in a highly developed area, suffers similar metal pollution problems. Beasley and Kneale (2002) cited as sources for heavy metal pollution in urban streams vehicles (tires, brakes, fuels and oils), pavement (concrete, asphalt), and surface debris (litter, winter road salts). Sediment entering the stream from construction sites, winter sanding activities, or soil erosion may also carry heavy metals and chloride. Negative effects of the heavy metals sampled here on macroinvertebrates and fish have been confirmed in several studies, and include impacts such as declines in the rates of growth and reproduction, reduced population size, and changes in community structure (Paul and Meyer 2001, and Beasley and Kneale 2002, and references therein).

If storm event data confirm that (some) heavy metals in Birch Stream exceed aquatic life criteria, airport, parking lot and road runoff should be diverted away from the stream or treated before it enters the stream. Furthermore, sand left in parking lots and on roads after the end of the winter sanding season should be removed to reduce the chloride and sediment influx into the stream.

Habitat Assessments

1. The flow regime in Birch Stream above the middle station was highly variable, with velocities above and below the Ohio Street bridge ranging from approximately 4 cm/s to almost 90 cm/s (Fig. 6). Right underneath the bridge, very little flow was measured, with velocities ranging from non-detectable (graphed as ~1 cm/s) to ~8 cm/s.

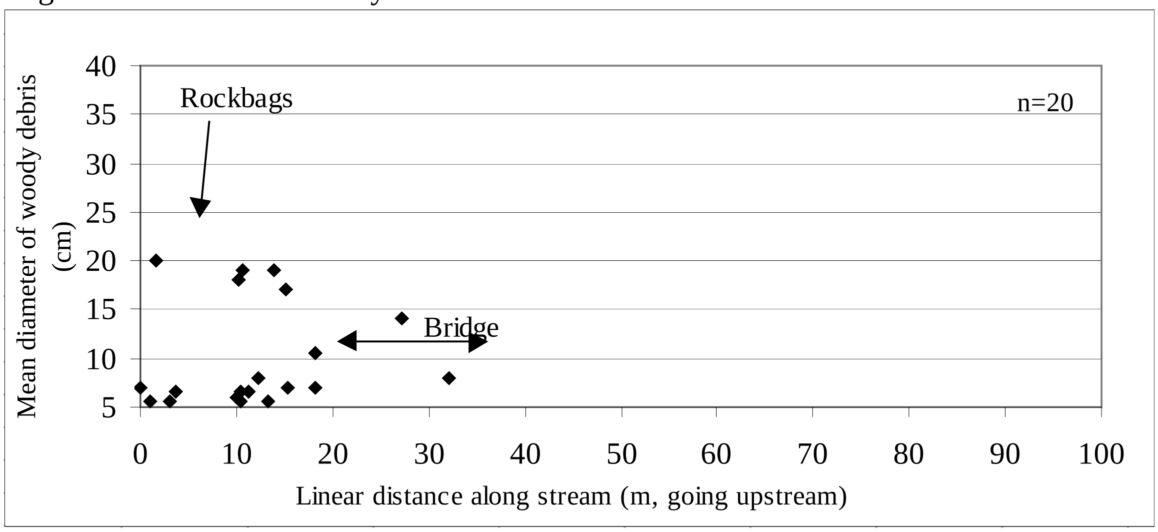
Fig. 6. Variability of flow velocity in Birch Stream



The variable flow pattern found above and below the Ohio Street bridge reflects the free-flowing and relatively natural (in terms of morphology) nature of this section of Birch Stream. A similarly variable flow regime is also present below the waterfall, down to where Birch Stream flows into Kenduskeag Stream, as well as further upstream towards the beaver dam, above which the flow becomes very slow and invariable (personal observation). The highly variable flow regime detected in the majority of Birch Stream is a positive feature as it provides aquatic organisms with a wide variety of environments to occupy, thus increasing the potential for a diverse biological community. Furthermore, fast flowing areas in small streams are usually associated with miniature "waterfalls" where the water tumbles over rocks, which contributes to a re-aeration of the water with dissolved oxygen. This re-aeration effect was detected in the dissolved oxygen data for the downstream station, which had healthy DO levels after the water had passed over a ~10 m tall waterfall (see Water Quality Monitoring, above).

2. The distribution of woody debris in the stream above the middle station was very uneven, with a good abundance (20 pieces) and size distribution (mean diameter of 5 to 20 cm) in the lower third of the stretch analyzed, i.e., from ~20 m below the Ohio Street bridge to right underneath the bridge (Fig. 7). Above that stretch, no woody debris was found.

Fig. 7. Distribution of woody debris in Birch Stream



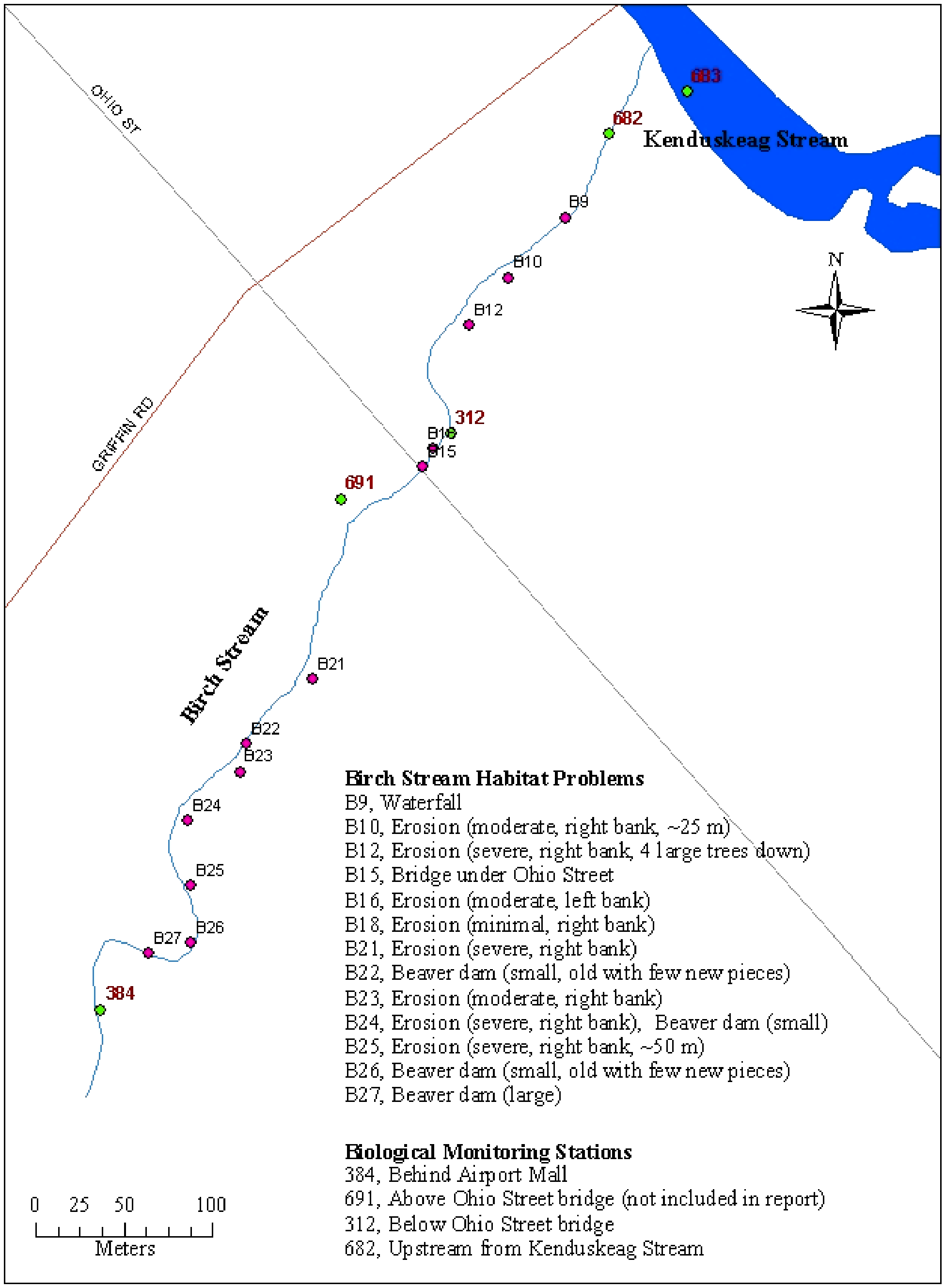
The abundance and size distribution of woody debris in Birch Stream reflects the availability of wood in the riparian zone, the area adjacent to the stream. Just below the Ohio Street bridge, the riparian zone consists of trees, shrubs, Japanese Knotweed, and a variety of grasses. The trees contribute to the woody debris in the stream, which enhances the habitat quality for aquatic organisms by providing stable attachment sites, providing and trapping organic materials to be used as food sources, trapping sediments, and increasing habitat diversity. Above the bridge most of the way to the Airport Mall, the riparian zone is essentially bare of trees or other woody plants, with grasses accounting for the large majority of vegetation. The absence of trees and hence woody debris significantly reduces the habitat quality for aquatic organisms in this stretch of Birch Stream in terms of habitat diversity and food supply. Trees represent a food supply in their own right once they have become woody debris, and they also provide leaf input, especially in the fall, which is an important food source for a variety of macroinvertebrates. A current problem in Birch Stream is the presence of a very active beaver who is in the process of taking down what few trees remain in the riparian zone above the Ohio Street bridge. While it would be highly advisable to replant the riparian zone in this section of the stream both to increase woody debris and to provide more shading of the stream, any replanting efforts would have to take the beaver presence into account by for example protecting newly planted trees with plastic or metal sleeves.

3. The stream habitat survey showed several areas with erosion problems, some of them severe (Fig. 8). Also noted was the presence of several beaver dams, which were removed on November 7, 2003, during a general stream clean-up. Apparently, the large dam has since been put back in by the beaver (E. Logue, MDEP, personal communication).

   The kinds of erosion problems identified during the habitat survey are often encountered in urban streams where stormflows in the stream bed are increased due to the effect of the surrounding impervious areas. As mentioned in the Introduction, impervious areas prevent the infiltration of rainwater into the ground, causing most of the water to run off into a nearby stream. Waterflows in urban streams are thus much higher during storm events, leading to erosion problems, especially in areas where the stream banks are already weakened due to the absence of the strong root systems of trees. Erosion affects aquatic communities by disturbing habitat and causing significant sedimentation problems. Increased stormflows in and of themselves also impair biological communities by literally “blowing out” many types of animals as well as habitat-forming structures (like woody debris).

   Erosion problems that occur close to physical structures such as houses or bridges need to be dealt with in order to safeguard those structures. However, unless the underlying causes, i.e., increased stormflows and weakend stream banks, are addressed, erosion problems will continue and, if dealt with, re-occur until the stream has reached a morphology that is capable of dealing with high water flows. The tree planting activities suggested in the previous section on woody debris would be a good first step in stabilizing banks, but major restoration efforts to stabilize the stream channel and banks will require the input of a professional engineer or a geologist specializing in the analysis of river systems (fluvial geomorphologist).

Fig. 8. Birch Stream Habitat Survey



The beaver dam below the Airport Mall affects the stream and the biological communities in a variety of ways, positive as well as negative. On the positive side is a potential mitigating effect of the dam on storm flows, which, in the absence of a dam, might be even more destructive than they currently are. Furthermore, the pond-like situation created by the dam essentially functions as an instream detention basin where sediment can settle out, thus reducing sedimentation problems in the stream. Also, some pollutants may settle out in the pond and become inactive. Finally, the pond functions as wildlife habitat for waterfowl and, of course, a beaver.

On the negative side, the pond in the summer likely acts as a heat reservoir that contributes to high water temperatures in the stream. The high water temperature of the pond and the low flow velocity in that area also contribute to a deterioration of the dissolved oxygen regime. Some pollutants can accumulate in the pond and reach unhealthy levels for aquatic organisms rather than getting flushed through the system quickly. And finally waterfowl can add nutrients to the stream if they occur in large numbers, while the beaver is destroying the few remaining trees in the riparian zone above the Ohio Street bridge.

A decision whether to remove the beaver dam, and trap and relocate the beaver, should be reached only after careful consideration of all factors mentioned above.

CONCLUSIONS

Biological communities (macroinvertebrates and fish) in Birch Stream were indicative of poor water and/or habitat quality. The diversity of animals present was low, and the majority of the species found are known to be tolerant to water pollution. An analysis of general water quality indicators (dissolved oxygen, conductivity, temperature) and chemical parameters (nutrients, bacteria heavy metals, chloride) indicated that Birch Stream shows many of the effects often encountered in urban areas, such as high water temperature, and elevated conductivity and nutrient levels. Habitat assessments also revealed evidence of typical urban stressors, such as an altered hydrology and resulting erosion problems. It is expected that as yet outstanding analytical results will further underscore the overall poor condition of Birch Stream.

In three previous years (1997, 1999, 2001), Birch Stream violated the aquatic life criteria for a Class B stream, and it is expected that the same will be true in 2003. As a result, the Maine Department of Environmental Protection is required to develop a TMDL (Total Maximum Daily Load) plan for the stream aimed at restoring aquatic communities to Class B standards. The data summarized in this report will form the basis for the TMDL plan to be developed in the winter and spring of 2004/2005. Other data not yet available, such as the macroinvertebrate identifications, water chemistry data from storm events, and the report from the fluvial geomorphologist also will be utilized in the development of a TMDL plan. At this point, it is not yet clear which types of pollutants, or which allowable pollutant levels (loads), will be specified in the TMDL plan to improve Birch Stream's macroinvertebrate community. Based on the information available to date, it seems likely that general recommendations such as those presented below will be taken into consideration in developing the TMDL plan.

List of recommendations:

- Removal of de-icer from the stream

  Note: the Maine Air National Guard and Bangor International Airport recently installed systems to control de-icer runoff from the airport complex. These new systems should help a great deal with improving overall water quality in the stream, although they by themselves are unlikely to solve all problems in Birch Stream and restore healthy aquatic communities.

- Reduction of the water temperature in the stream
  - Replanting of the riparian zone above the Ohio Street Bridge would provide shading that can aid in keeping water temperatures low.
  - A reduction in the temperature of the airport/road/parking lot runoff before it enters the stream may be achieved for example by channeling runoff through stormwater treatment systems.
  - Removal of the beaver dam (and relocation of the beaver) may be considered to eliminate the pond-like situation below the Airport Mall as this may be acting as a heat reservoir in summer (note that many factors need to be considered before a decision on the removal of the dam can be made).

- Increase in the dissolved oxygen level in the stream
  - A reduction in water temperatures would likely improve the dissolved oxygen levels as cool water can hold more oxygen than warm water.
  - If stormwater treatment systems are installed to treat runoff, they could be equipped with oxygenation units to increase the oxygen level in the discharged water.
  - Removal of the beaver dam (and relocation of the beaver) may be considered to eliminate the pond-like situation below the Airport Mall as the low flow velocity and high water temperature in this area negatively affect dissolved oxygen levels (note that many factors need to be considered before a decision on the removal of the dam can be made).

- Reduction in the nutrient and metal levels in the stream
  - General Best Management Practices such as keeping pets away from the stream, picking up pet waste, ensuring that any septic systems in the watershed are in good working order, and that lawns in the vicinity of the streams are not fertilized would help reduce the nutrient problems in Birch Stream.
  - Removal of solid particles to which many nutrients and metals adhere would help in reducing pollutant loads; this could be achieved for example by channeling runoff through a stormwater treatment system.

- Improvement in habitat quality in the stream and riparian zone
  - Replanting of the riparian zone above the Ohio Street Bridge would stabilize stream banks thus improving stream habitat stability.

  - Replanting of the riparian zone furthermore would add valuable woody debris to the stream thus improving habitat quality and food supply.

  - A reduction in stormflow volume would reduce the erosive force of stormflows, thus stabilizing in-stream habitat and reducing sedimentation problems; stormflow volumes could be reduced, for example, through the installation of detention basins.

  - A further reduction of sedimentation problems could be achieved by ensuring that sand left on parking lots and roads after the end of the winter sanding season is removed, and that construction companies employ Best Management Practices aimed at containing sediment on site.

  - Note: the report from the fluvial geomorphologist will provide valuable insight into the evolving morphology of Birch Stream, and advice on how to address erosion problems.

The list of recommendations given above only serves as a general example of the types of actions that could be taken on Birch Stream to deal with some urban stressors. Detailed recommendations tailored to the specific stressors identified for Birch Stream will require the input of experts from fields such as biology, geology, and engineering.

Restoring healthy aquatic communities in Birch Stream will require collaboration among several parties (regulatory agencies, the City of Bangor, Maine Air National Guard, Bangor International Airport, concerned citizens), as well as financial resources and time. De-icer treatment systems installed on the airport complex are an excellent first step but more work needs to be done. The TMDL plan to be developed by the Maine Department of Environmental protection will define allowable loads for particular pollutants such as sediment, and implementation of the plan should lead to a considerable improvement in stream health over the next few years. Future monitoring is advisable to determine whether the TMDL achieved its goal of restoring the resident aquatic communities to Class B standards in Birch Stream, or whether additional actions are required.

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